REGENESIS®

IN SITU STABILISATIE van PFAS-verontreiniging in grond en grondwater met Colloïdale Actieve Kool

ir. Kris Maerten

Technical Manager Europe

23 Januari 2025

- **30** jaar
- **>30,000** projecten wereldwijd
- **Iedere dag** gebruikt

Onze visie

➔ **PFAS zit overal!**

➔ **Nauwelijks beschikbare saneringstechnieken**

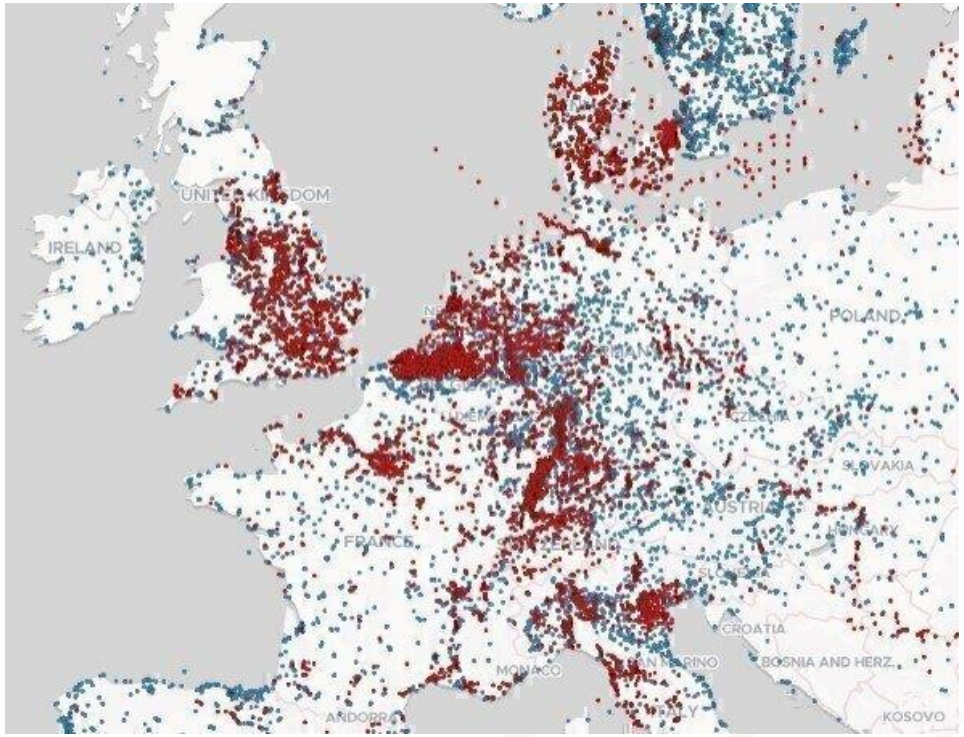
- Wat met kosten, afvalstroom, duurzaamheid?

➔ **Duurzamere saneringsaanpak?**

Interstate Technology Regulatory Council (ITRC) - 2020:

Remediation is the

'a process used to reduce or eliminate the risk for humans and the environment that may result from exposure to harmful chemicals'



https://www.lemonde.fr/en/les-decodeurs/article/2023/02/23/forever-pollution-explore-the-map-of-europe-s-pfas-contamination_6016905_8.html

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Risico

Risico kan ook worden weggenomen door blootstelling te vermijden

In situ sorptie - gestimuleerde attenuatie

Maar PFAS breekt niet af?

Natuurlijke attenuatie betekent niet enkel afbraak, maar ook:

- Diffusie
- Dispersie
- Volatilisatie
- Sorptie
- Chemische (abiotische) afbraak

Verhoogde capaciteit van bodem om PFAS te adsorberen
'Retentie'
=**Gestimuleerde attenuatie** van PFAS pluim

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RESEARCH NOTE

WILEY

Enhanced attenuation (EA) to manage PFAS plumes in groundwater

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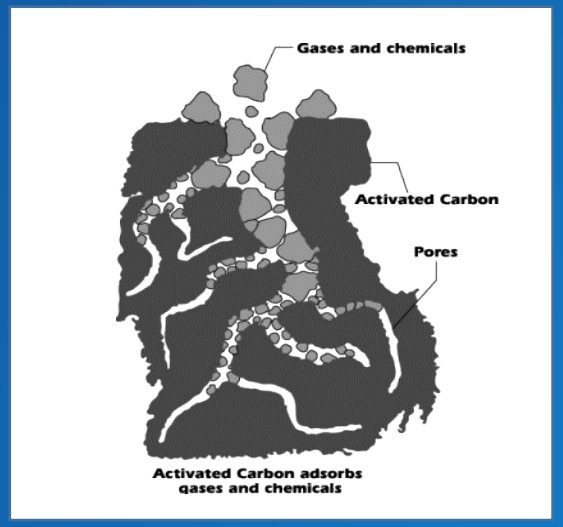
Abstract

Remediation of per- and polyfluoroalkyl substances (PFAS) in groundwater is particularly challenging because of their unique chemical and fate and transport properties. Many conventional in-situ remediation technologies, commonly applied to address other groundwater contaminants, have proven ineffective for treatment of PFAS. Given their stability, destruction of PFAS in-situ has remained elusive as an in-situ treatment option. Consequently, new approaches to manage PFAS groundwater plumes are of great interest to environmental practitioners. We propose that enhancing PFAS retention can play an important role in reducing PFAS mass flux and providing long-term protection of downgradient groundwater receptors. Enhanced retention of PFAS fits directly into the enhanced attenuation (EA) framework, an established groundwater remediation strategy that was developed in the first decade of the 2000s for other groundwater contaminants. In this paper, we propose eight EA approaches for PFAS in groundwater, including technologies that are currently being implemented at PFAS sites (e.g., injection of particulate carbon amendments), applications of conventional remediation technologies to PFAS sites (e.g., capping to retain PFAS in the vadose zone), and novel, innovative approaches (e.g., intentional food grade LNAPL emplacement to retain PFAS) for enhanced PFAS retention. These EA approaches leverage the properties of PFAS to (i) facilitate sorption to conventional and novel sorbents, (ii) concentrate PFAS at air/water interface via gas sparging, and/or (iii)

Colloïdale Actieve Kool: SourceStop en PlumeStop



1 – 2 µm diameter (zoals bacterie, rode bloedcel)
Suspensie in water (of vaste conglomeraat)

Goede verspreiding in ondergrond

- Geen hoge injectiedrukken noodzakelijk

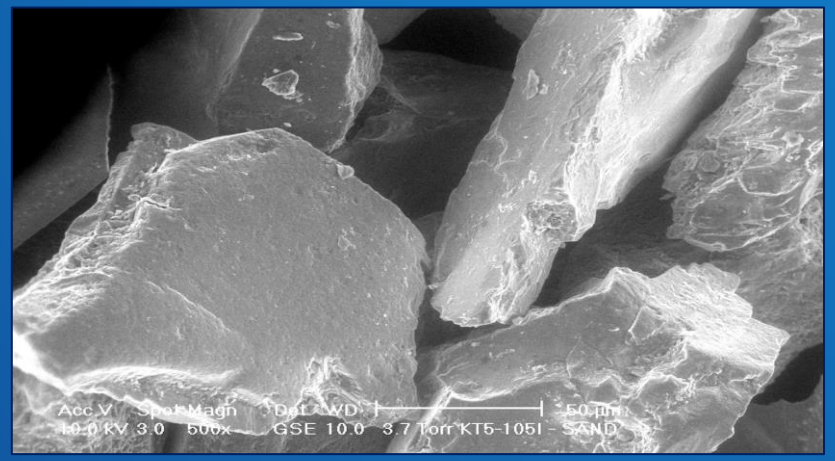
'coaten' van de bodempartikels

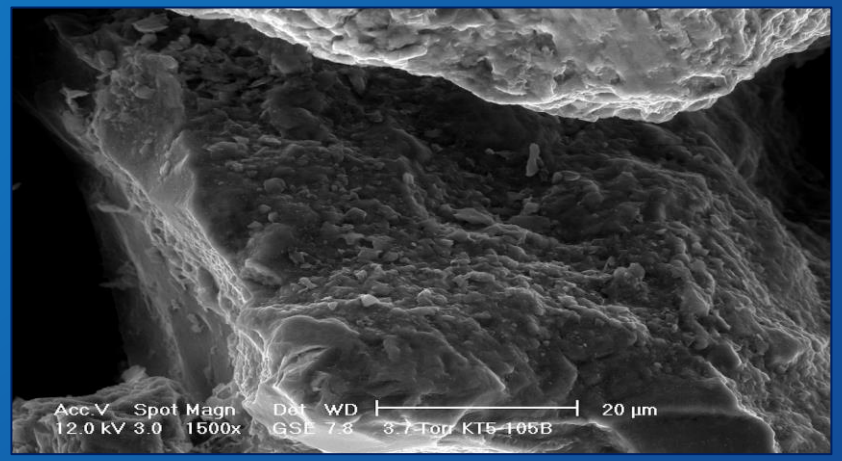
- Vorming ondergrondse AK filter

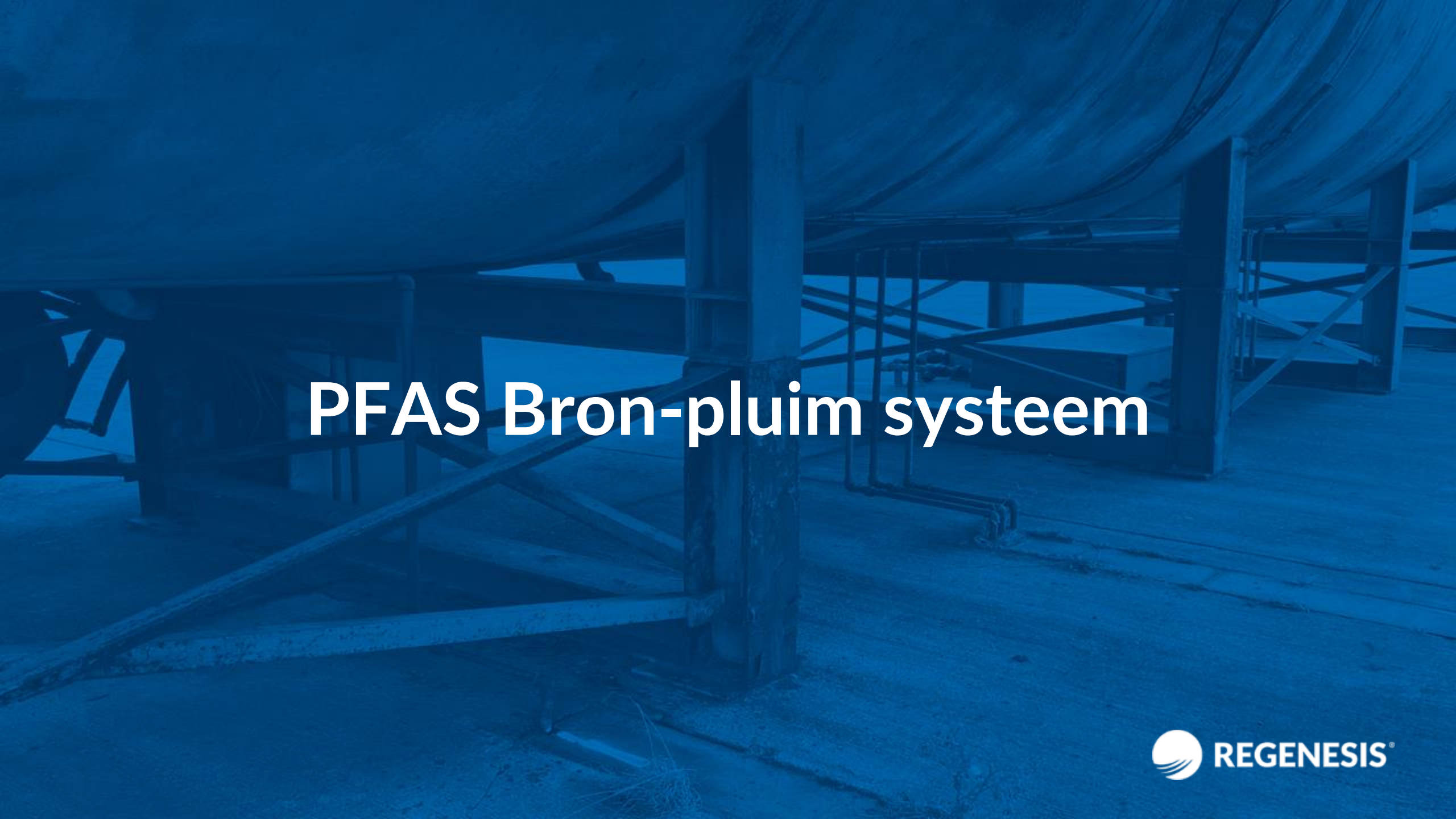
Heel snelle sorptie van PFAS

- Meer buitenoppervlak
- Kortere afstand tot sorptiesites dan bij GAK

Xiao, Ulrich, Chen & Higgins. Environ. Sci. Technol. 2017, 51, 6342-6351







PFAS Bron-pluim systeem

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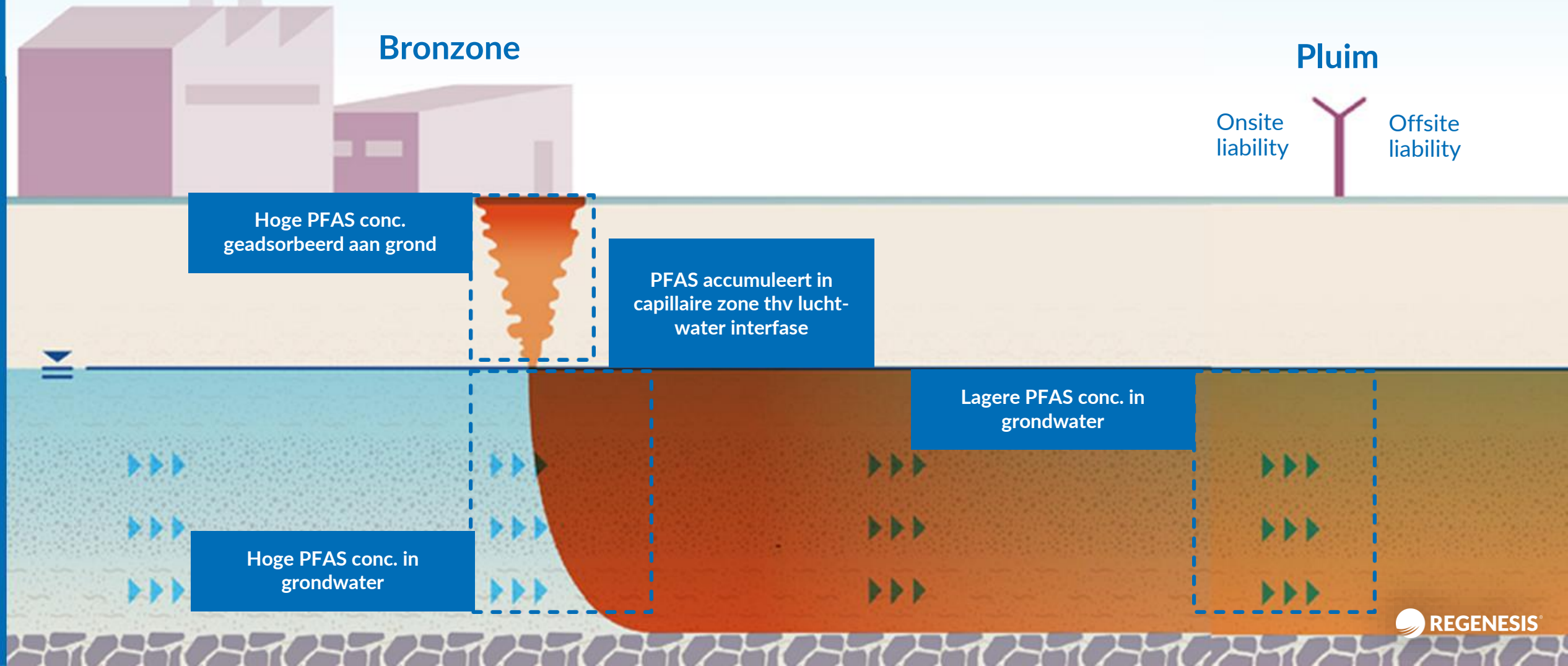
PFAS Bron-pluim systeem

PFAS Bron-pluim systeem



PFAS Bron-pluim system

SourceStop®

PLUME STOP®

Liquid Activated Carbon

REGENESIS®

PLUME STOP®

Liquid Activated Carbon

SourceStop®

- **Twee verschillende samenstellingen**
- **Aanpasbare en zeer efficiënte behandeling van met PFAS verontreinigde bodem en grondwater in brongebieden**
  - Reduceert uitloogbaarheid van PFAS in de grond
  - Stopt significante nalevering naar grondwater
- **Beide formules maken gebruik van REGENESIS' Colloidal Activated Carbon**

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SourceStop – Liquid Formulation

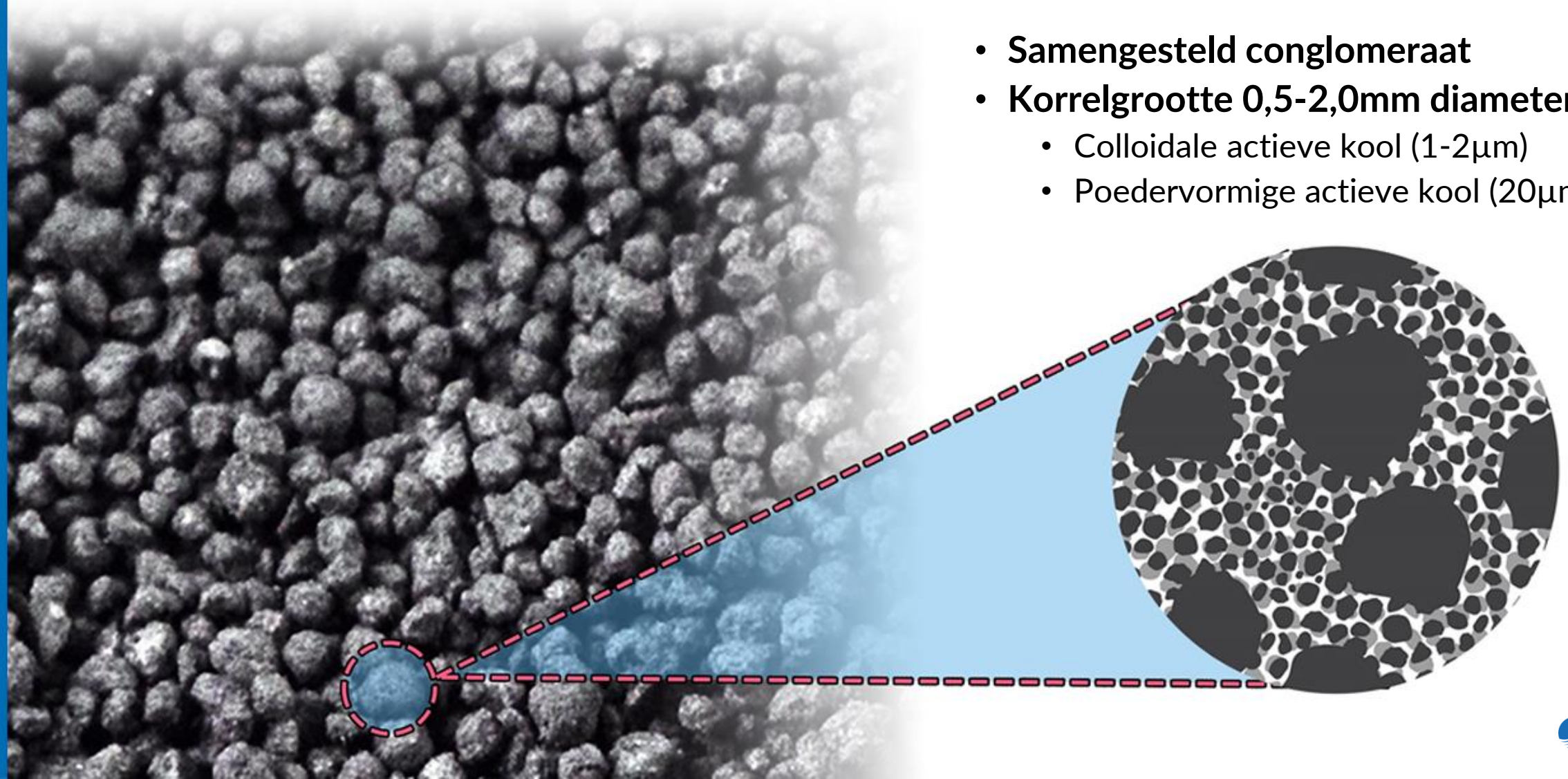
- Enkel Colloidale Actieve Kool
- 1-2µm partikel grootte
- In suspensie in water met behulp van toeslagstoffen
- Goede verspreiding in ondergrond (lage druk)
- ‘Coaten’ van bodempartikels

Toediening via injectie

Waar toepassen:

- Capillaire zone
- Hoge concentraties in grondwater
- Bodem ontgravingsputten (bv. ontgravingen tot in grondwater!!)
- Sleuven voor nutsvoorzieningen

SourceStop – Solid Formulation



- **Samengesteld conglomeraat**
- **Korrelgrootte 0,5-2,0mm diameter:**
  - Colloidale actieve kool (1-2µm)
  - Poedervormige actieve kool (20µm)

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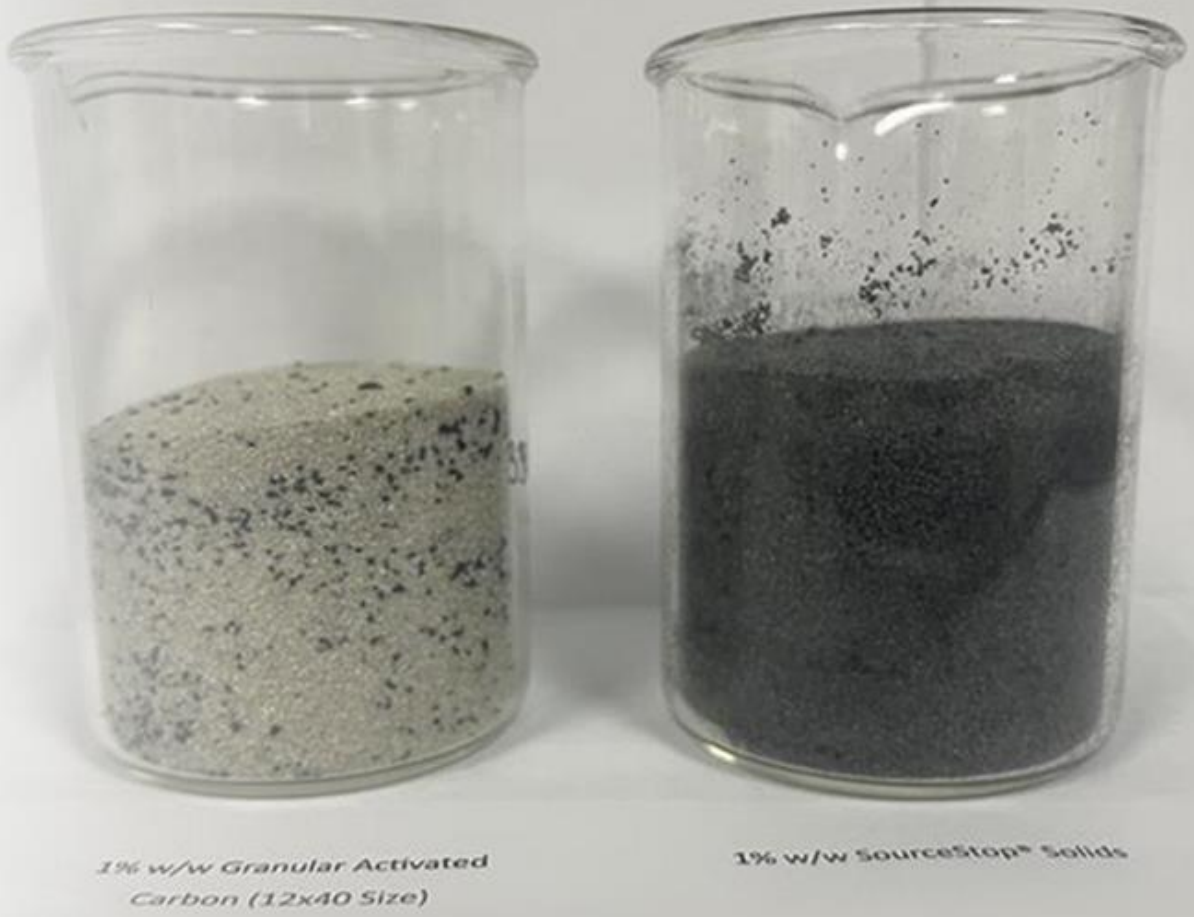
SourceStop

Menging en coating

- **Minder stofvorming/veilig!**
- **Dringt dieper door en coat de grond**
  - Colloidale actieve kool komt vrij
  - Verbeterde distributie
  - Dringt dieper door en coat de grond
  - Belangrijk bij minder doorlatende bodems
  - Minimale mengtijd – en kost

- **Mengt snel en gemakkelijk**
  - Conglomeraat valt snel uiteen bij menging
    - Mechanisch
    - Bodemvocht/infiltrerend (regen)water
  - Duidelijk zichtbaar wanneer grond goed is vermengd



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Stofbeperking

Toepassing SourceStop

Toepassing PAK

Voorbeelden

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Veldtoepassingen

Bronbehandeling- Grayling, MI

Locatie	Michigan
Behandeld oppervlak	20 m^2
Behandeld diepte-interval	0 – 3 m-mv
Max. PFAS in percolaat	3835 ng/l
Geology	zandig
Datum van toepassing	September 2022

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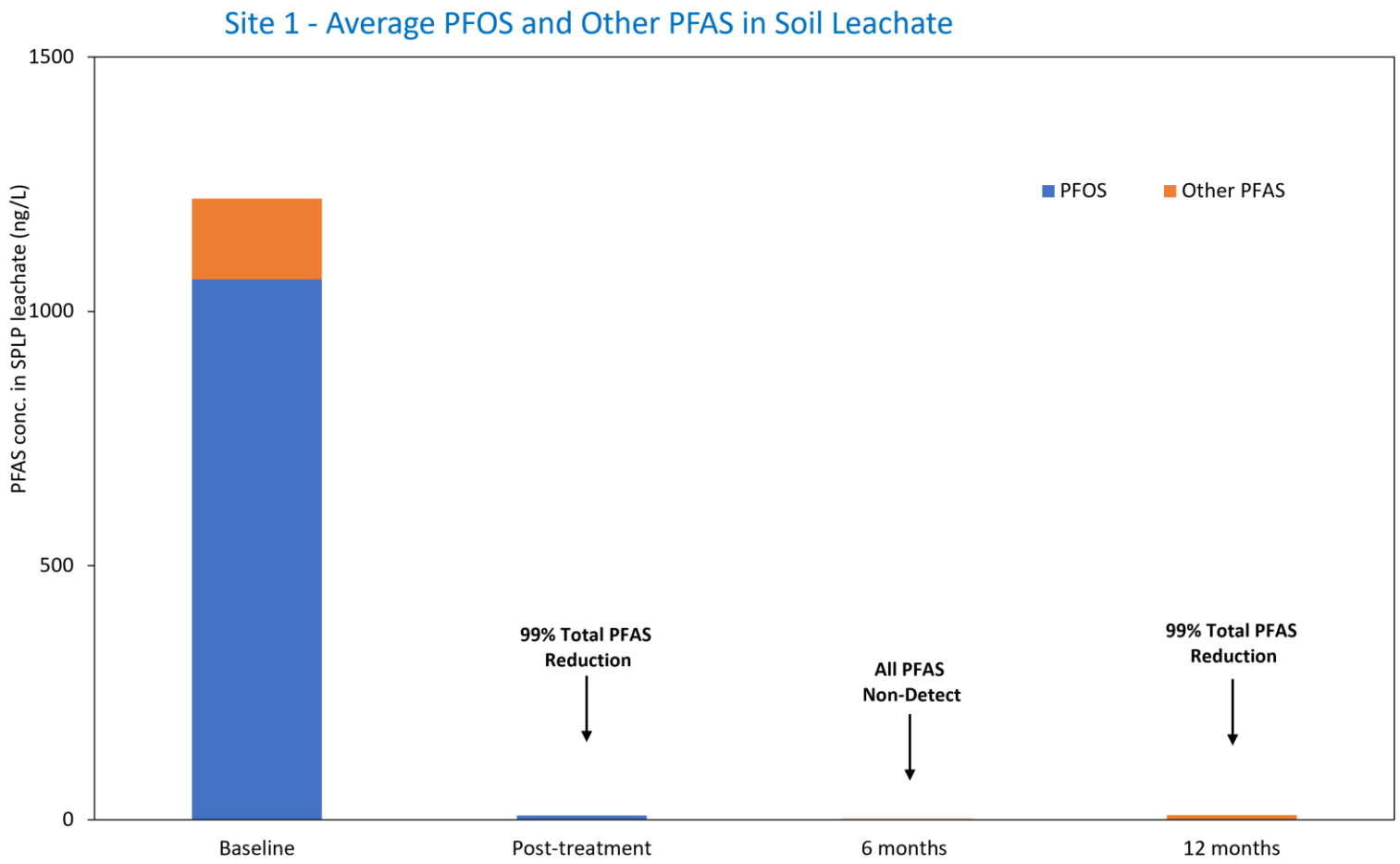
Veldtoepassingen

Bronbehandeling- Grayling, MI

Gem. PFOS/PFAS concentraties in pecolaat voor en na behandeling

- PFOS
- Rest of PFAS



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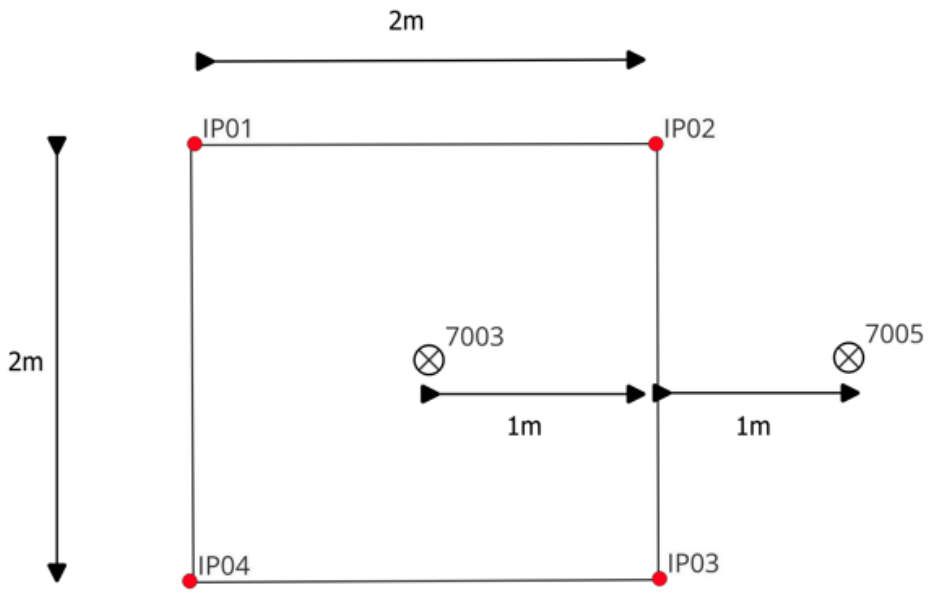
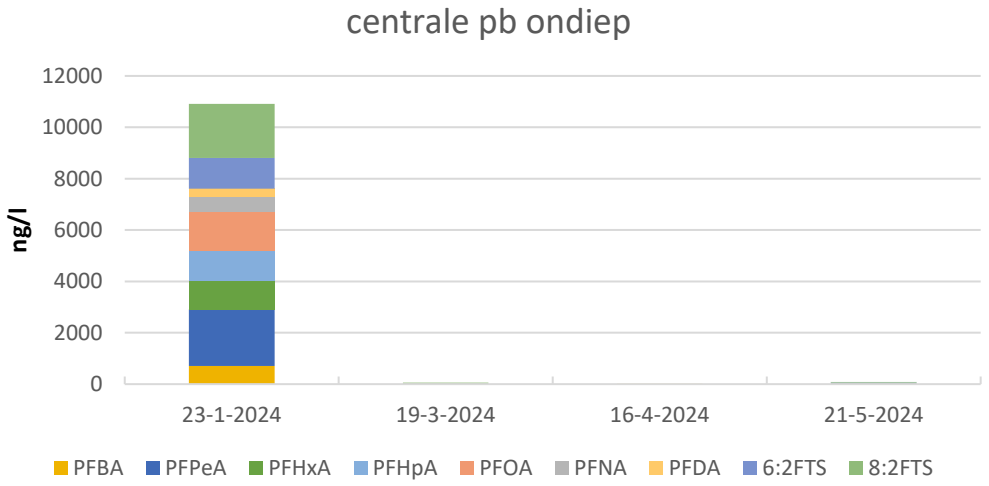
Veldtoepassingen

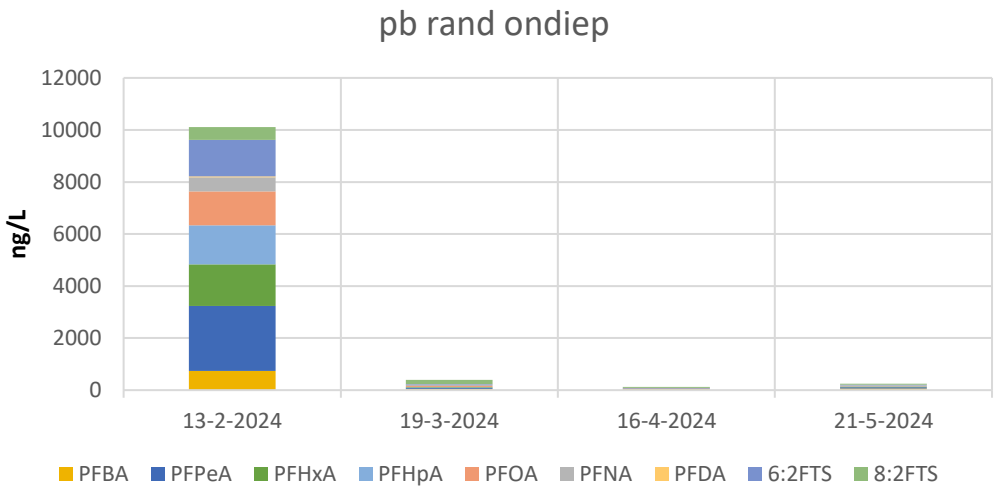
Bronbehandeling- Vlaanderen (piloot)

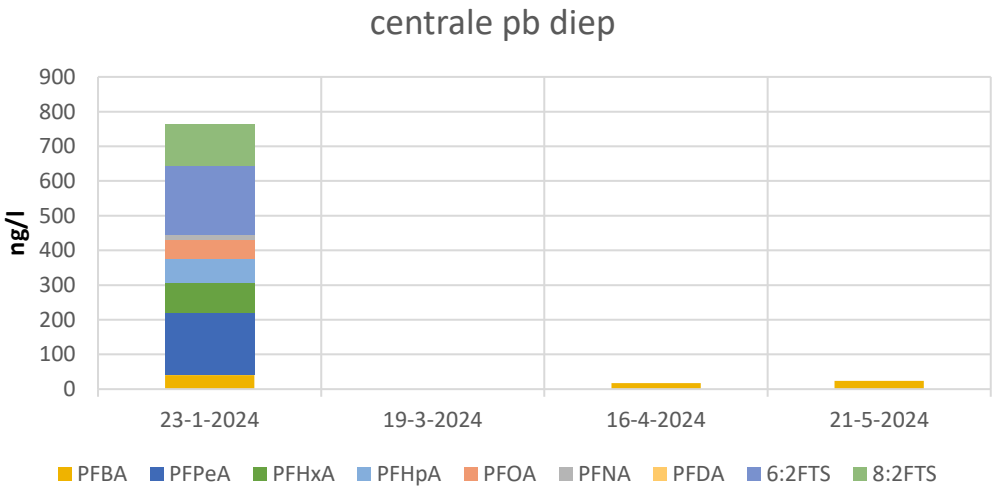


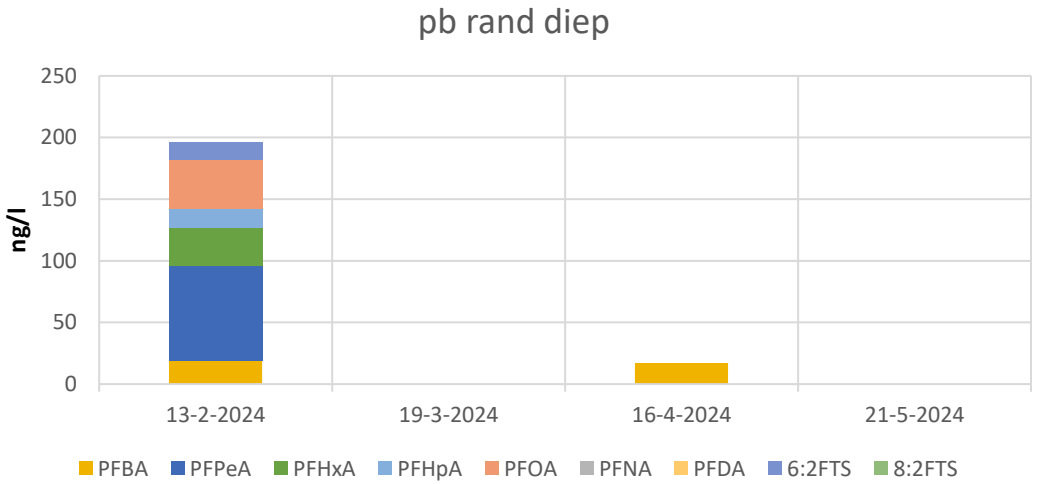
Veldtoepassingen

Bronbehandeling- Vlaanderen (piloot)









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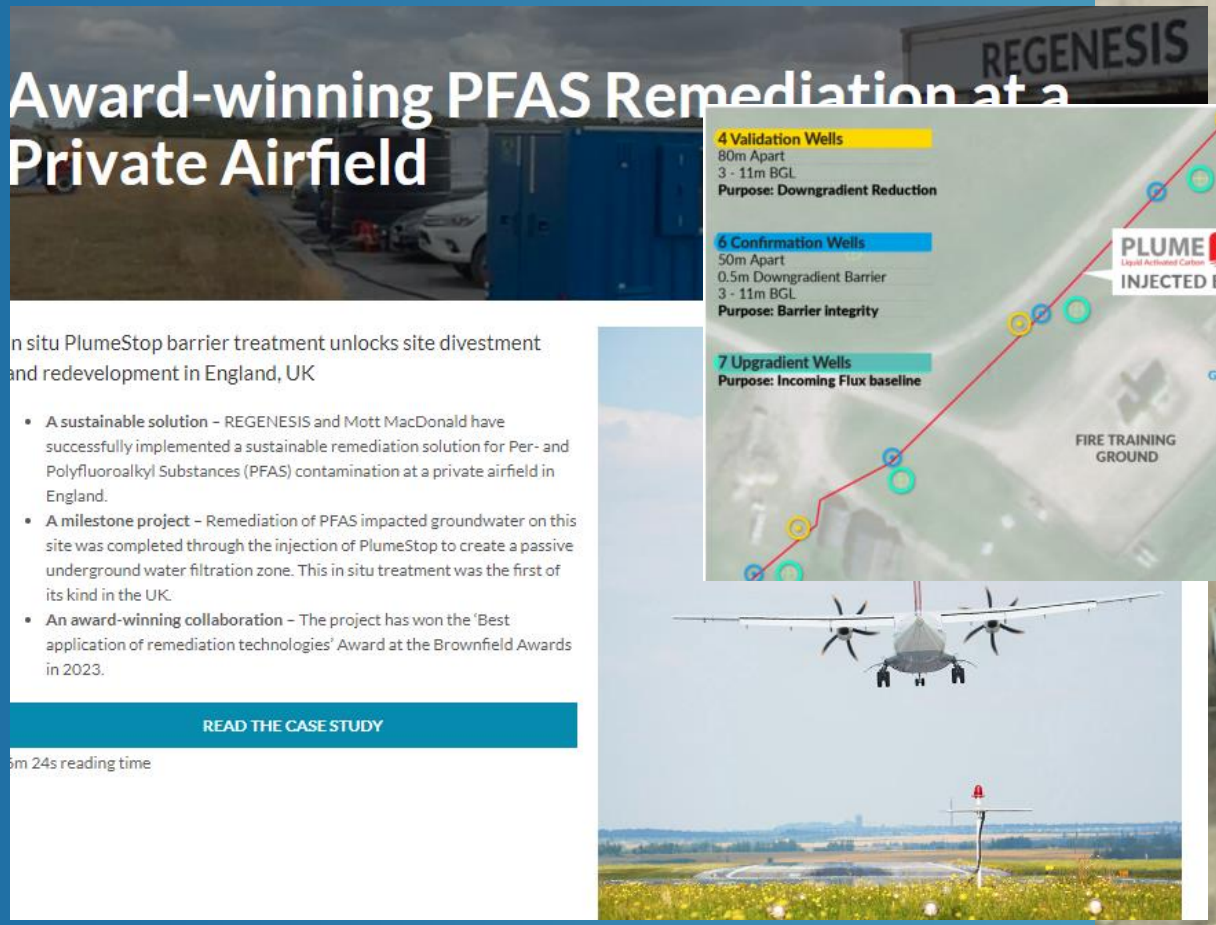
PlumeStop®


REGENESIS
Award-winning PFAS Remediation at a Private Airfield
n situ PlumeStop barrier treatment unlocks site divestment and redevelopment in England, UK
A sustainable solution – REGENESIS and Mott MacDonald have successfully implemented a sustainable remediation solution for Per- and Polyfluoroalkyl Substances (PFAS) contamination at a private airfield in England.
A milestone project – Remediation of PFAS impacted groundwater on this site was completed through the injection of PlumeStop to create a passive underground water filtration zone. This in situ treatment was the first of its kind in the UK.
An award-winning collaboration – The project has won the 'Best application of remediation technologies' Award at the Brownfield Awards in 2023.
READ THE CASE STUDY
m 24s reading time

4 Validation Wells
80m Apart
3 - 11m BGL
Purpose: Downgradient Reduction
6 Confirmation Wells
50m Apart
0.5m Downgradient Barrier
3 - 11m BGL
Purpose: Barrier integrity
7 Upgradient Wells
Purpose: Incoming Flux baseline
PLUME STOP
INJECTED BARRIER
GROUNDWATER FLOW
FIRE TRAINING GROUND
SITE BOUNDARY
0
25
50m

PlumeStop®


4 Validation Wells
80m Apart
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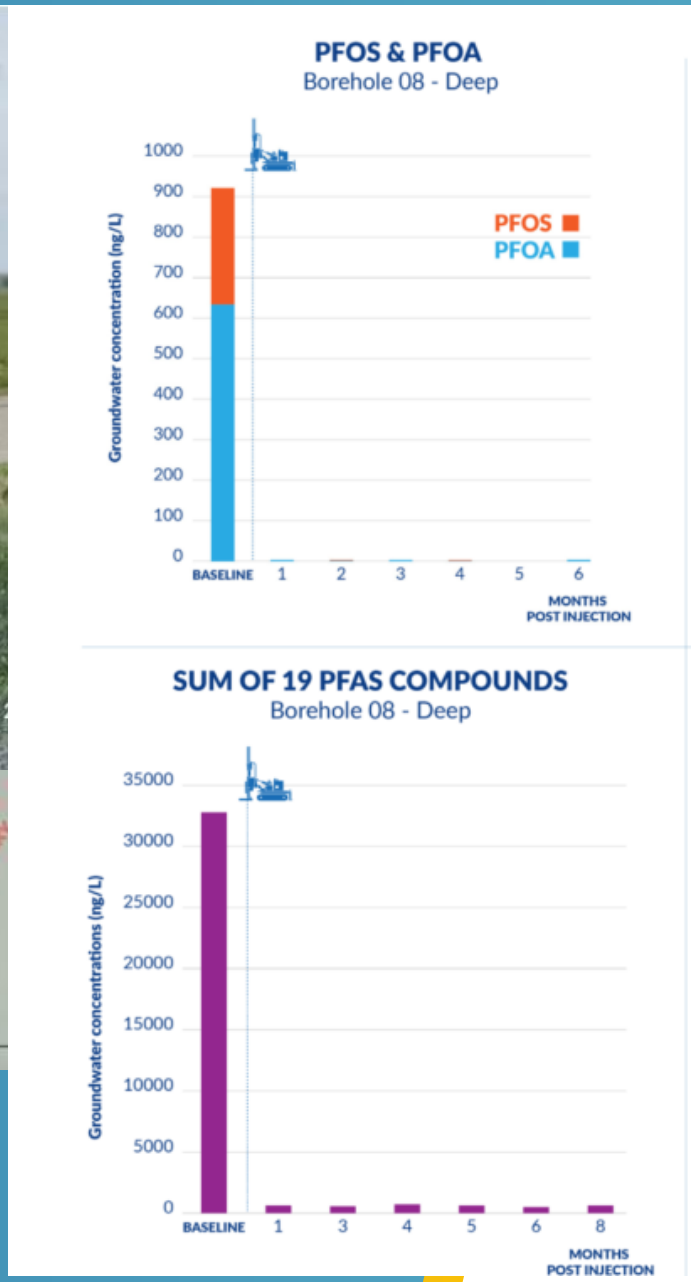
Liquid Activated Carbon
INJECTED BARRIER
GROUNDWATER FLOW
FIRE TRAINING GROUND
SITE BOUNDARY
0
25

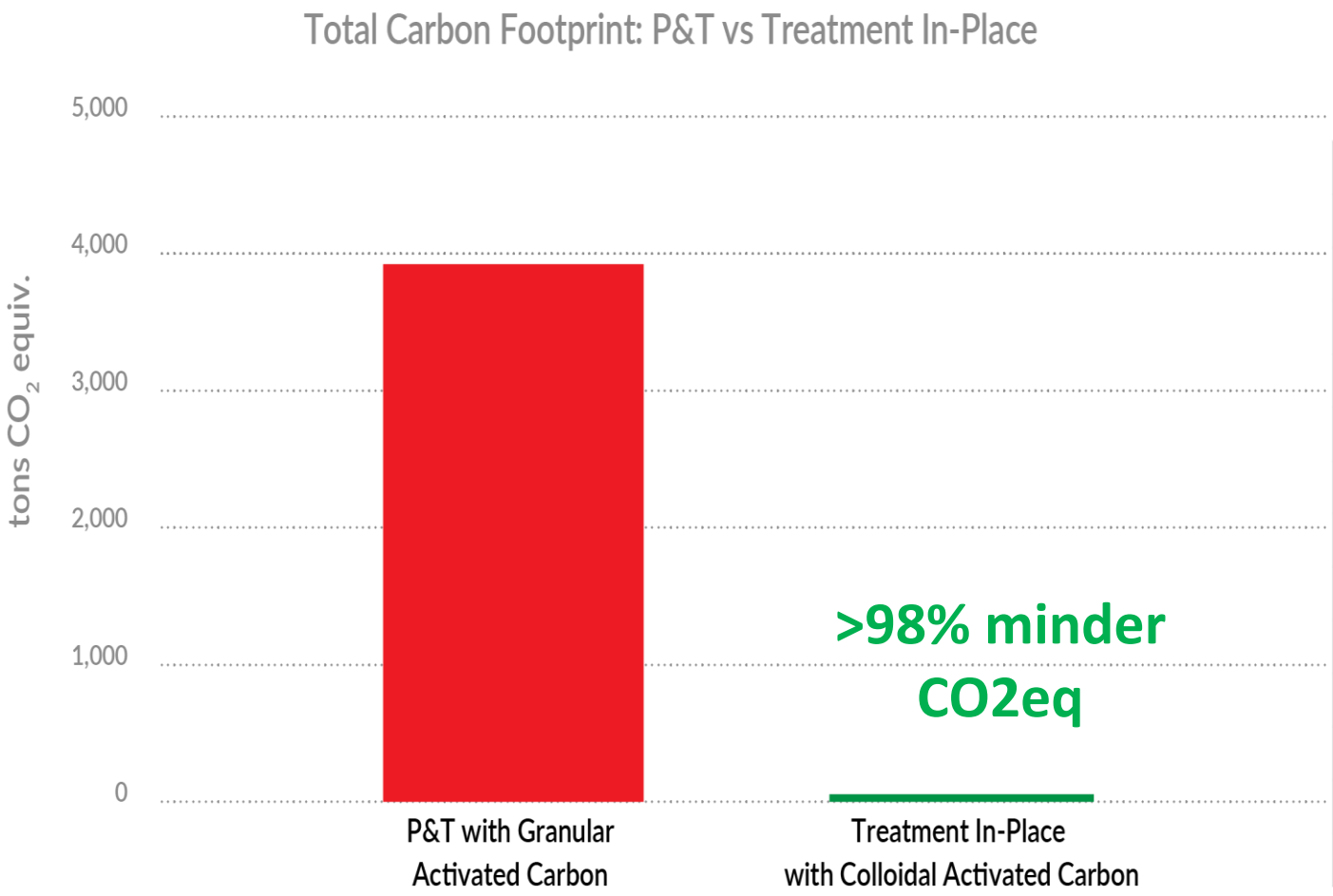
© REGENESIS


PFOS & PFOA
Borehole 08 - Deep
Groundwater concentration (ng/L)
PFOS
PFOA
BASELINE
MONTHS POST INJECTION
PFOS & PFOA
Borehole 08 - Shallow
SUM OF 19 PFAS COMPOUNDS
Borehole 08 - Deep
Groundwater concentrations (ng/L)
SUM OF 19 PFAS COMPOUNDS
Borehole 08 - Shallow

Duurzaamheidstudie

REGENESIS®

Koolstofvoetafdruk



>98% minder CO2eq

Koolstofvoetafdruk = 70 x kleiner

	PlumeStop	P&T w/ GAC
Remediation equipment		15,2
Civil works		
Fixed installations	0,05	0,9
Machinery	1,0	1,3
Remediation and operations		
PlumeStop / GAC	50,5	2 860
Electricity		281
Maintenance		3,6
Monitoring	4,0	4,0
Waste management		
Hazardous waste		112
Wastewater treatment		644
Total carbon footprint	**56**	**3 922**

Bewezen techniek

PLUME STOP®
Liquid Activated Carbon

SourceStop®

60+

Veldtoepassingen

178

In ontwerp/overweging

REGENESIS®

Wetenschappelijke artikelen

1. Is het concept erkend?

- U.S. EPA. Use of Monitored Natural Attenuation for Inorganic Contaminants at Superfund Sites, Directive 9283.1-36. Published online 2015.
- *Newell CJ, et al. Monitored Natural Attenuation to Manage PFAS Impacts to Groundwater: Scientific Basis. Groundwater Monitoring & Remediation. 2021;41(4):76-89.*
- *Newell CJ, et al. Monitored natural attenuation to manage PFAS impacts to groundwater: Potential guidelines. Remediation Journal. 2021;31(4):7-17.*
- *ER21-5198. Accessed December 15, 2021.*

2. Werkt het in de praktijk?

- McGregor, R. (2020) Distribution of Colloidal and Powdered Activated Carbon for the in Situ Treatment of Groundwater. *Journal of Water Resource and Protection*, 12, 1001-1018

3. Is de wetenschap betrouwbaar?

- Carey GR, McGregor R, Pham ALT, Sleep B, Hakimabadi SG. Evaluating the longevity of a PFAS *in situ* colloidal activated carbon remedy. *Remediation Journal*. 2019;29:17–31.
- McGregor R. In Situ treatment of PFAS impacted groundwater using colloidal activated carbon. *Remediation Journal*. 2018;

Wetenschappelijke artikelen

4. Is de hypothese getest?

- Zhao, Y. (2021). The in situ treatment of TCE and PFAS in groundwater within a silty sand aquifer. *Remediation Journal*, 1–11

5. Zijn de resultaten herhaalbaar?

- Hakimabadi, S. G., Singh, M., McGregor, R., Woodfield, C., Van Geel, P. J., & Pham, A.-T. (2022). Longevity of colloidal activated carbon for in situ PFAS remediation at AFFF-contaminated airport sites. Remediation, 1–21.
- McGregor R. Six pilot-scale studies evaluating the in situ treatment of PFAS in groundwater. *Remediation Jounal*. 2020;30:39-50. https://doi.org/10.1002/rem.21653

6. Is het kosteneffectief, op de lange termijn?

- Birnstingl, J., Wilson, J. (2024). A Cost Comparison of Pump-and-Treat and In Situ Colloidal Activated Carbon for PFAS Plume Management, *Remediation Journal*, 2024; 35:e70005, https://doi.org/10.1002/rem.70005

Meer informatie

➔PFAS: Aanpak bron-pluim

➔ Webinar opnames

➔ Case studies

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Vragen?

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Connect on LinkedIn

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